Design for the Environment Program
Office of Research and Development

Lithium-ion Batteries and Nanotechnology Partnership

What Is EPA's Design for the Environment Program?

EPA's Design for the Environment (DfE) Program is a voluntary, partnership-based program that works with industry to integrate health and environmental considerations into business decisions. DfE's approach typically focuses on evaluating the health and environmental risks or life-cycle impacts of traditional and alternative technologies, materials, and processes. Since its inception, DfE has formed cooperative partnerships with the electronics industry, including:

- Assessing the life-cycle impacts of lead solder and lead-free alternatives, and
- Evaluating new and current materials that can be used to meet fire safety requirements for circuit boards.

DfE partnerships have also conducted life-cycle assessments of cathode-ray tube and flat-panel displays, and wire and cable insulation and jacketing, and evaluated alternative lead-free surface finishes and cleaner technologies for making holes conductive step in printed circuit board (or printed wiring board) manufacturing. Read information on safer chemical-intensive (e.g., cleaning) products that bear the DfE logo. (Link to epa.gov/dfe.)

What Is EPA's Office of Research and Development?

EPA's Office of Research and Development, the scientific research arm of EPA, conducts research on ways to prevent pollution, protect human health, and reduce risk. Work at ORD laboratories, research centers, and offices across the country helps improve the quality of air, water, soil, and the way we use resources. (Link to epa.gov/ord.)

Assessing Life-Cycle Impacts of Lithium-ion Batteries

What Are the Partnership's Goals?

EPA's Design for the Environment Program and the Office of Research and Development formed the Lithium-ion Batteries and Nanotechnology Partnership in June 2009 to conduct a screening-level life-cycle assessment (LCA) of current and emerging energy systems used in hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and electric vehicles (EVs). The energy systems of interest include currently manufactured lithium-ion (Li-ion) battery technologies and a next-generation battery component (anode) that uses single-wall carbon nanotube technology. The primary goal of the partnership is to help companies make environmentally sound process and material choices.

When completed, it is expected that the life-cycle assessment results can be used by the Li-ion battery industry to identify the materials or processes within a product's life cycle that are likely to pose the greatest impacts or potential risks to public health or the environment. In addition, given the use of nanotechnology in current and future Li-ion battery products, the LCA will also promote nanotechnology innovations in advanced batteries that result in reduced overall environmental impacts, including greenhouse gas emissions.

The project partners include individual Li-ion battery manufacturers, research institutions, battery recycling companies, the Department of Energy's Argonne National Laboratory, and EPA. The current list of partners include Altairnano, Inc., Electrovaya, EnerDel Lithium Power Systems, Johnson Controls-SAFT, Novolyte Technologies, Kinsbursky Brothers, Inc., Rochester Institute of Technology, Rechargeable Battery Association, NextEnergy, National Alliance for Advanced Transportation Batteries (NAATBatt), Umicore Group, and Environmental Defense Fund.

The partnership is evaluating the following energy product systems:

- High-power density Li-ion batteries currently manufactured by our partners for HEV and PHEV applications;
- High-energy density Li-ion batteries currently manufactured by our partners for EV and PHEV applications; and
- Single-wall carbon nanotube anode technology for use in next-generation Li-ion batteries.

High-energy density batteries deliver moderate amounts of energy over a long period of time (i.e. sustained energy), which is important for long-distance for EV and PHEV applications. High-power density batteries deliver large amounts of energy over a short period of time (i.e. energy bursts), which is necessary for quick accelerations for HEV and PHEV applications. The partnership may also compare the impacts during the "use stage" of energy systems that use Li-ion batteries in electric vehicles with those of lead-acid batteries in gasoline vehicles, on a functional unit basis (impacts per kilometer). The life-cycle assessment study is being conducted with the assistance of Abt Associates Inc., under contract with EPA.

What Is Life-Cycle Assessment?

This project will examine the full life cycle of the energy systems and estimate environmental impacts from each of the following major life-cycle stages:

- Raw materials extraction/acquisition;
- Materials processing;
- Product manufacture;
- Product use; and
- Final disposition/end-of-life.

There are four major phases of an LCA study, as described in the International Organization for Standardization (ISO) 14040 standard:

- Goal definition and scoping;
- Life-cycle inventory;
- Life-cycle impact assessment; and
- Interpretation of results.

In the first phase of the study, the goals and scope are defined by the project partners, including which products and technologies are to be evaluated. Next, life-cycle inventories (LCIs) are compiled for all processes within the life-cycle stages contained within the LCA scope. Following completion of the LCIs, the environmental life-cycle impacts of the products/ technologies are objectively assessed, using the LCI data. Finally, the results are summarized and analyzed, with a discussion of limitations and uncertainties.

Why Is the Partnership Evaluating Li-ion Batteries?

The production and use of hybrid and electric vehicles are necessary to alleviate the United States' dependence on oil, and to prevent future climate change – two key priorities of the Obama Administration. To address these priorities, the Administration has established a near-term goal of 1 million electric drive vehicles on the road by 2015, including HEVs, PHEVs, and EVs. Li-ion battery technologies will be critical to meeting this goal, due to their increased energy storage capability, which will increase electric vehicle marketability.

This project will also highlight a nanotechnology application that has the potential to reduce environmental impacts. Although some nanomaterials and technologies are already being used in Li-ion batteries, further and novel uses of nanomaterials may increase the storage capacity and life of these batteries.

For example, battery anodes made from single-wall carbon nanotubes are being developed and are included in this study. These anodes show promise for increased current capacity, extended electric vehicle range and battery life, and reduced recharge cycle time.

A quantitative environmental life-cycle analysis of Li-ion batteries used in electric drive vehicles—and the nanomaterials and nanotechnology used to produce some of them—has not yet been conducted. Such a study is needed to help grow the industry for advanced-vehicle batteries in an environmentally responsible and efficient way.

This project offers the opportunity to mitigate current and future impacts and risks by:

- Assisting battery manufacturers and suppliers to identify which materials and /or processes are associated with the greatest environmental impacts throughout the life cycle of their products, and
- Identifying areas that could benefit from increased energy efficiency.

The project also is timely, given that the use of Li-ion batteries for electric vehicles is an emerging technology and that recent government programs are encouraging the growth of the industry in the United States.

The LCA will provide useful information to the advanced-automotive battery industry, and particularly to the Li-ion battery industry for electric vehicles. The partnership's study will provide the industry with an objective analysis that evaluates the potential life-cycle environmental impacts of selected Li-ion battery systems, and help determine whether these systems present environmentally preferable options to existing systems, such as the use of lead-acid batteries in internal combustion engines.

How Can I Get More Information?

To learn more about the DfE Program or the Lithium-ion Batteries and Nanotechnology Partnership, or to view an electronic version (or order a hard copy) of this fact sheet (document #EPA 744-F-09-001), visit the Office of Pollution Prevention and Toxics' DfE Program Web site: epa.gov/dfe